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Surface Mine Reclamation at the Elkins Mine Drainage Demonstration Project After 17 Years

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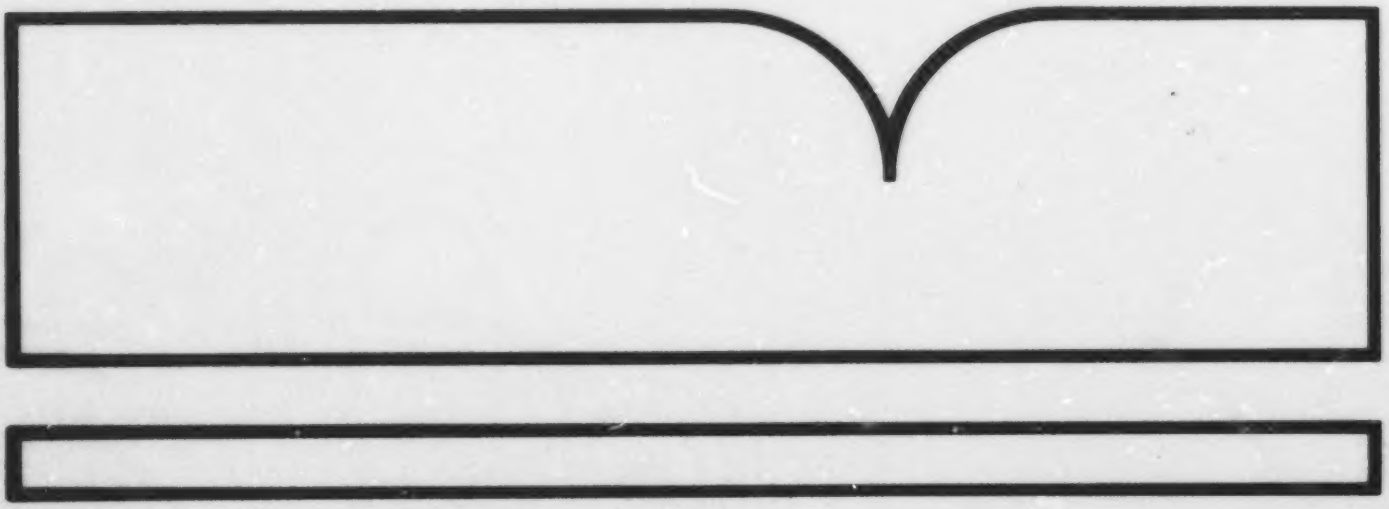

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Ronald D. Hill
and
Walter E. Grube, Jr.
Land Pollution Control Division
Hazardous Waste Engineering Research Laboratory

HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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16. ABSTRACT

In 1968 approximately 640 acres of land disturbed by coal mining were reclaimed and revegetated. The revegetation approach included the use of lime and fertilizer followed by seeding with a grass/legume mixture. In the steeper areas pine trees were also planted. In areas designated for forest planting, a mixture of pines and deciduous trees was utilized. The revegetated areas were evaluated in 1971, 1973, 1976, 1984, and 1985. This paper discusses the results of the latter two evaluations. After 17 years observations show that a substantial degree of long-term success has been achieved with the revegetation approach taken. The introduced vegetative cover either persisted or was replaced by a higher successional order. Shortleaf and Virginia pine were the most successful conifers planted. Black alder had been a good nurse tree but died after 10 years. S. lespedeza was the superior legume. Soil pH was in the range of 3-5, with the best cover occurring at the higher pH.

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by

Ronald D. Hill and Walter E. Grube, Jr.
Land Pollution Control Division
Hazardous Waste Engineering Research Laboratory
U.S. Environmental Protection Agency
26 W. St. Clair Street
Cincinnati, Ohio 45268

Abstract. In 1968 approximately 640 acres of land disturbed by coal mining were reclaimed and revegetated. The revegetation approach included the use of lime and fertilizer followed by seeding with a grass/legume mixture. In the steeper areas pine trees were also planted. In areas designated for forest planting, a mixture of pines and deciduous trees was utilized. The revegetated areas were evaluated in 1971, 1973, 1976, 1984, and 1985. This paper discusses the results of the latter two evaluations. After 17 years observations show that a substantial degree of long-term success had been achieved with the revegetation approach taken. The introduced vegetative cover either persisted or was replaced by a higher successional order. Shortleaf and Virginia pine were the most successful conifers planted. Black alder had been a good nurse tree but died after 10 years. S. lespedeza was the superior legume. Soil pH was in the range of 3-5, with the best cover occurring at the higher pH.

Introduction

In 1964, a mine drainage demonstration project was undertaken near Elkins, West Virginia.[1,2] The project area contained a large coal drift mine (3,000 acres) which had been extensively surface-mined along the outcrop. The unique features of this project were its size and the revegetation methods used. Over 12.5 miles of surface mines were reclaimed. Approximately 640 acres of land disturbed during reclamation were revegetated in the spring of 1968.

At the time of this project, the surface mine reclamation state-of-the-art consisted of minimal grading to cover the coal seam and planting of trees (usually pine) on 6-foot centers. Rarely was fertilizer or agricultural limestone applied to the soil to improve conditions for plant establishment or growth.

New technologies demonstrated at the Elkins Demonstration Project (EDP) included special grading patterns to cover the coal seam and pit, the covering of acid producing spoil material, and the use of grasses for reclamation. In areas where the highwall was unstable, the spoil and highwall were graded to cover the highwall (approximate original contour). In areas where the highwall was considered stable, the highwall was left and the spoil regraded to promote drainage away from the highwall (called "swallowtail" backfill).

After regrading in 1967, soil samples were collected from numerous sites across the areas to be revegetated. These were analyzed for available plant nutrients, pH, and lime requirement by standard agricultural soil test procedures. Based on the results of these soil tests, agricultural limestone was applied over all areas to be reclaimed, at a rate of 2 to 4 tons per acre. Fertilizer was applied to each area at the rate of 1,000 pounds of 10-10-10 per acre.

Grasses and legumes were planted immediately for rapid cover and erosion control. (See Table 1 for a listing of the species.) On the flat areas, normal farm machinery was used to prepare the seedbed and sow the seed. On steep slopes a hydroseeder was used to apply seed and hydromulch.

Trees were planted on the steeper slopes and forest specified areas. The steeper outslopes were hand-planted with a grab mixture of pines (Table 1). In some areas Japanese larch, black alder, and black locust were also planted. The forest planting utilized a new approach, i.e., five to six rows of a grab mixture of pines were planted followed by five to six rows of deciduous trees including black alder, yellow poplar, cottonwood, and white oak.

Table 1. Vegetation Species Planted in 1968 and Observed in Study Plots in 1985.

	Species planted	Rate	Species observed; Remarks	Volunteers observed; Remarks
Area 100	Scotch pine (Pinus sylvestris) White pine (Pinus strobus) Virginia pine (Pinus virginiana) Shortleaf pine (Pinus echinata)	grab mix on 6 ft. centers	28 Shortleaf and 1 Scotch pine seen of 60 originally planted on the area measured. 50% survived. Heights ave. 26.7 ft. with ave. dbh of 4 in. All conifers appeared to be in good health.	Shortleaf pine: 10, up to 6 ft. ht. Cottonwood: 4, up to 15 ft. ht. Yellow poplar (Liriodendron tulipifera): 2 of 7 ft. ht. Maple: (Acer spp.): 6, up to 14 ft. ht.
Area 30	Scotch pine, Shortleaf pine, Virginia pine, White pine Black alder (Alnus glutinosa) Sericea lespedeza (Lespedeza cuneata) Tall fescue (Festuca arundinacea) Tall oat grass (Arrhenatherum elatius) Weeping lovegrass (Eragrostis curvula) Kentucky bluegrass (Poa pretensis)	grab mix, 6 ft. centers 15#/A 10#/A 10#/A 5#/A 5#/A	Shortleaf pine: 15 of 25 ft. ave. ht. & 5.6 in. ave. dbh. White pine: 14 of 32 ft. ave. ht. & 6.0 in. ave. dbh. 25% of all pines planted survived. Tall fescue: intermixed with other species in complete ground cover. Sericea lespedeza: intermixed with other species in ground cover. Black alder: 1 observed in poor health. No lovegrass was seen.	Cherry (Prunus serotina): 6, up to 19 ft. ht. & 3.1 in. dbh. Maple: 3, up to 18 ft. ht. & 2 in. dbh. Elm (Ulmus rubra): 1, of 8 ft. ht. Wild strawberry (Fragaria chiloensis): a few scattered plants. Milk weed (Asclepias syriaca): a few scattered plants. Ironweed (Veronia baldwini): common, dominated ground cover. Sericea lespedeza: heavy growth in one area about 10x20 ft. Moss (Polytrichum spp.): common at borders of and within acidic seep areas. Mixed fescue and unidentified grasses and weeds: covered entire plot area to knee ht.
Area 2	Black alder (Alnus glutinosa) Japanese larch (Larix leptolepsis) Black locust --- hydroseeded (Robinia pseudoacacia) Cottonwood (Populus deltoides) Rye grass (Lolium perenne) Sericea lespedeza (Lespedeza cuneata) Tall fescue (Festuca arundinacea) Tall oat grass (Arrhenatherum elatius) Barley (Hordeum vulgare)	600/acre, hand planted 6#/A 5#/A 15#/A 10#/A 10#/A 5#/A	One larch was observed near the top of the outslope. No alder planted were seen. No locust planted were seen. No cottonwood planted were seen. Lespedeza flourished and dominated in patches a few tens of ft. in dimension at highwall base, on inner bench, in treeline area, & on outer bench. Oatgrass covered a section of inner bench, but was spotty and sparse across the remainder of the section studied. Fescue was sparsely observed across the section studied.	Maples comprised the dominant volunteer woody species; several ave. 32' ht. at base of highwall; 11 on inner bench, up to 9' ht; 6 around drainage area, up to 6' ht; 18 up to 18' ht. from road to treeline; several at treeline up to 26' ht; several on outer bench up to 25' ht; and maples dominated on out-slope. Cottonwood was most visible: 3 at base of highwall, of 33', 41', & 50' ht; one of 29' ht. between road and treeline; one of 40' and several ave. 24' ht. in treeline area; two of 22' ht. on outer bench and one of 48' ht. at top of outslope; outslope's largest tree was a cottonwood of 13" dbh. Black locust: one of 18' ht. in highwall colluvium; a few, up to 5' ht. seen on the outer bench; and a few, one of 40' ht. along the top of the outslope. Yellow poplar, wild cherry, wild grape, and sassafras were interspersed along the highwall colluvium; few cherry were also scattered within the overall plot. Scattered blackberry plants were consistently found in sparsely vegetated soil areas. Ironweed dominated large segments of the inner bench and outer bench regions, and was conspicuous throughout the entire plot studied. Moss (Polytrichum spp.) occupied several sq. yd. along road, and spots within the inner bench. Ground pine (Lycopodium spp.) noted at several spots, intermixed with other plants. Bromesedge (Andropogon virginicus) was evident in isolated clumps within the inner bench, drainageway, and road/treeline regions.

In 1971, 1973, and 1976, an evaluation of the revegetation was undertaken and reported upon. This paper discusses the 1984 and 1985 evaluations.

Procedures

In 1984, 16 years after the reclamation had been completed, a selected team of technical experts, many of whom had been involved with the project in the 1960's, devoted 3 days to making visual observations of the status of reclamation. The review team examined eight areas (over 550 acres) as designated in the 1968 reclamation plan.[1] Lands reclaimed for stabilization by pine plantings, afforestation by mixed species, grassland for land stabilization, mixed grass and trees for wildlife, and pasture intended for intensive use were represented.

During the 1985 study, four plots were selected for detailed evaluation. A plot in Area 100 was selected as a control. Area 100 had been revegetated according to the state-of-the-art being used by the mining industry in the early 1960's. Two plots were selected in Area 30 in a section that had been planted with the conifer/deciduous tree mixture. In Area 2 a plot 100 feet wide reaching from the base of the highwall to the spoil outslope (approximately 300 feet) was selected to represent areas where the bench had been planted with grass/legumes only and the outslope with a combination of grass and trees.

The plot locations were based on an attempt by the investigators to select areas that best represented the total area. Plot 30-1 was selected first and its size based on a width equal to six rows of pines and six rows of deciduous trees (71 feet) as originally planted and a length of the same. The plot in Area 100 extended from near the base of the old highwall to the top of the outslope, and included five rows of trees. An arbitrary 100-foot wide strip was selected within Area 2 and designated Plot 2-1.

Most trees in the plots were identified, their height estimated, their diameter at breast height (dbh) measured, and their health noted. Adjacent grasses, legumes, and other plants were also observed.

Five pits were excavated in order to inspect plant roots and soil properties in each area studied. One pit was located in Plot 100 under a pine tree; two pits were located within Plot 30-2, one within the pine tree area and one in the deciduous tree area; and two pits were dug within Plot 2-1, one in a region devoid of any vegetation, and the other within a region heavily overgrown with lespedeza. The pH of the soil samples was determined in the laboratory.

Discussion of Results

Area 100

The only reclamation work undertaken in Area 100 had been the covering of the coal seam with spoil material. The spoil bank at the test plot was about 90 feet wide and sloped toward the highwall at 20 percent. In March 1968, agricultural limestone was applied to the surface at the rate of 2.5 tons per acre and the area was hand-planted with a grab mixture of pines (see Table 1). The test plot selected in Area 100, 30 feet wide and 71 feet long (Figure 1), included five rows of trees. Approximately 60 trees would have been planted. In June 1985, 29, or about 50 percent of the original trees still survived (Figure 1). All but one of the pines were a Shortleaf. The remaining one was a Scotch. The heights of the trees ranged from 16 to 40 feet with an average height of 27 feet. The dbh ranged from 1.3 to 7.0 with an average of 4 inches. Five trees had twin trunks. All the trees appeared in good health. In addition to the planted trees, several volunteer trees had been established in the more open areas. Volunteers were not present under the pine trees. Maples were the predominant volunteers ranging in height from 3.5 to 14 feet with the majority about 7 feet. Other volunteers were yellow poplar and cottonwood. Seed source trees were near for each of these. Pine reseeding from the planted trees was also occurring in one area.

Pine needle litter comprised the only soil cover observed on this plot area. No grasses, weeds, etc., had volunteered here. The soil pit excavated under a pine tree exhibited roots (pine) below the 20-inch depth. The surface 6-inches were dominated by a black shale; below this, brown colors of iron oxides were prominent. Samples were taken and laboratory pH determined (Table 2). The pH was 4 in the upper 2 inches and decreased with depth to 2.9 at 14-18 inches.

Area 30

Area 30 contained 19.7 acres and was contour-graded because of the poor condition of the highwall. The revegetation plan called for 2 tons per acre of limestone (applied April-May 1968), a seeding of grass and legumes (Table 1), and 1,000 pounds per acre of 10-10-10 fertilizer. The seed and fertilizer were applied in May 1968. Hydroseeding (14.8 acres) was used on the steep banks. In addition, six rows of black alder followed by six rows of a grab mixture of scotch, white, and shortleaf pine were hand-planted in this area.

A superb growth of fescue developed the first year. By the third year an outstanding growth of S. lespedeza had taken over a large section. Survival of alder was about 90 percent. By 1972 these trees were 10 to 14 feet tall. Survival of pine was approximately 70 percent. The pines were about 2 feet tall; the slow growth was believed to result from competition by the grass.

By 1976 the survival of black alder had declined from 90 percent to 50 percent because of a fungus infection. Many of the alder were over 20 feet tall. The pines had about 35 percent survival and the white and scotch were 10 to 15 feet tall. The shortest were 6 to 8 feet tall. Cover of the entire area approached 100 percent.

Two test plots were examined within Area 30 in 1985. They were replicates of a six-row alder plus six-row pine block (Figures 2 and 3). In Plot 30-1, approximately 72 alders and 72 pines were originally planted. By 1985 all the alders were dead. Stumps from seven dead alder trees were found, some with 4- to 6-inch diameters. Within the alder tree area there was a thick, knee-high cover of grass and weeds. Ironweed

Table 2. Soil pH 17 Years After Reclamation

	Plot				
depth(in)	100	30-2(c)	30-2(d)	2-1(nv)	2-1(v)
0-2	4.0	4.5	4.8	3.6	4.4
2-4	3.6	4.8	4.9	3.6	4.4
4-6	3.2	4.6	4.9	3.5	4.4
8-10	3.2	4.7	4.9	3.4	3.9
12-14	3.0	nd	4.8	3.4	nd
14-18	2.9	4.7	nd	nd	3.3

c = conifer tree area
d = deciduous tree area
nv = non-vegetated area
v = vegetated area
nd = not determined

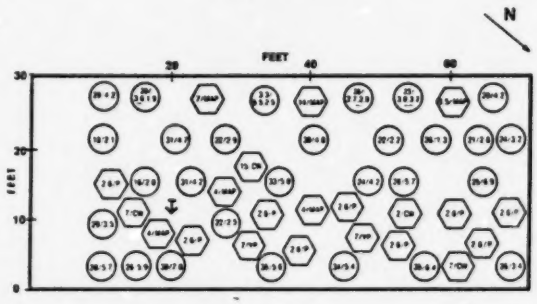

Figure 1: Conifer Survival And Volunteer Invasion On Area 100 After 17 Years.

Legend

○ - Planted Trees	SPECIES OFTREES
⬡ - Volunteer Trees	MAP - Maple
xx/ABC - height in feet/Species	CW - Cottonwood
xx/yy.zz - height in feet/dbh in inches	YP - Yellow Poplar
yy - dbh (diameter at breast height)	P - Pine
zz - dbh of second major trunk	CH - Cherry
⊗ - Stump From Dead Alder	ELM - Elm
↧ - Soil Pit	BA - Black Alder

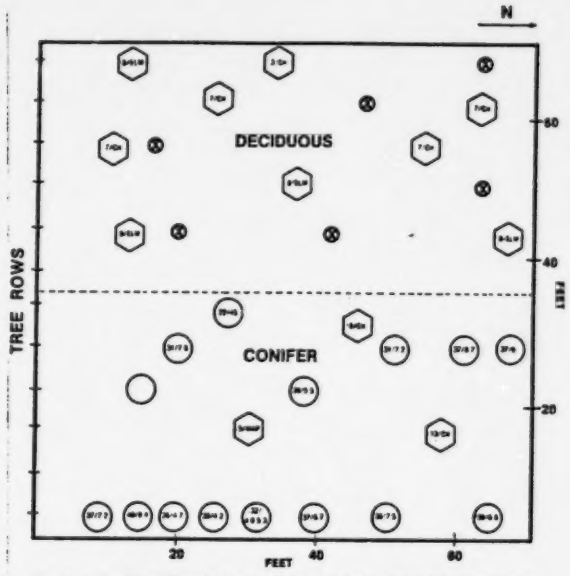

Figure 2: Tree Survival And Volunteer Invasion On Area 30-1 After 17 Years.

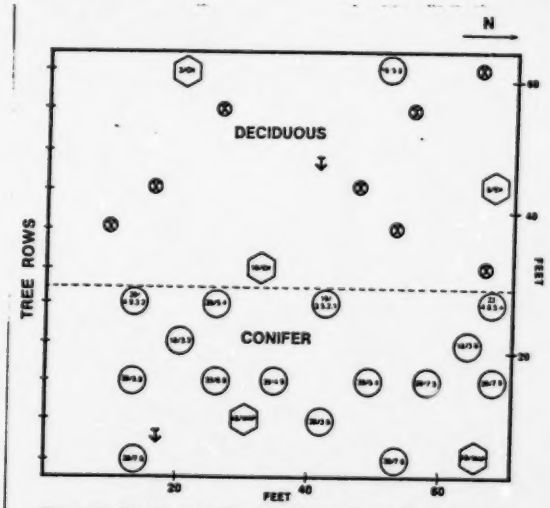

Figure 3: Tree Survival And Volunteer Invasion On Area 30-2 After 17 Years.

(Veronia baldwini) was the predominant plant. Other plants found were fescue, milkweed, wild strawberries, and numerous other unidentified weed species. There were also four volunteer trees, three cherries (Prunus serotina, 3 to 7 feet tall), and one 8-foot elm (Ulmus ruba).

The conifer area of Plot 30-1 contained 16 pines (4 shortleaf and 12 white) or 22 percent of the trees planted. The shortleaf pines were as tall as 31 feet and had a dbh range of 4.5 - 7.6 inches. The white pines ranged in height from 26 to 40 feet with an average of 32 and the dbh ranged from 4.0 to 9.0 inches with an average of 6.7. All but one of the pines appeared to be in good health. In a majority of the area, the tree canopy was complete and there was only a minimum of grass and weeds in the undercover. A heavy layer of needles was present. In those areas not shaded out, there was a heavy growth of grass and weeds. Three volunteer trees were located within the pines--one 6-foot cherry, one 5-foot maple, and one 13-foot cherry.

In Plot 30-2 there were six rows of alder and five rows of pine planted or 72 alder and 60 pines. By 1985 all but one alder were dead. The lone survivor was 26 feet tall with a dbh of 5.8 inches and in poor health. Eight dead alder stumps were present. Three cherry trees had volunteered into the area ranging in height from 3 to 19 feet. The tallest had a dbh of 3.1 inches. There was a 100 percent ground cover in the alder area with the predominant plants being ironweed and fescue. There were also spots with lespedeza, wild strawberries, and mosses, as well as a number of other unidentified weedy plants.

The pine area had 15 trees representing 25 percent survival. All of the pines were

shortleaf and ranged in height from 18 to 29 feet with an average of 25 feet, and a dbh range of 2.1 to 7.6 inches with an average of 5.3. All appeared in good health. There were two volunteer maples--one 10 feet and the other 18 feet tall. The undercover was approximately 60-70 percent complete with plants, and 95 percent complete with plants and needle litter. There were no large bare areas. One 10 x 20-foot spot had a heavy growth of lespedeza.

Two soil pits were excavated to depths of 17 inches, one each in the conifer and deciduous areas of Plot 30-2. The soil pit in the deciduous area was within a region completely covered with ironweed vegetation. Roots were observed to the base of the soil pit. The soil was brownish colored with little evidence of coaly or black shale parent materials. Table 2 shows the pH values obtained at several depths and shows the pH to be relatively constant at 4.8. The soil pit within the conifer area was between rows of planted trees, where a row of trees had been planted but had died off earlier. Ironweed was also dominant here, but pine needles and other leaf litter covered about 2 inches on the soil-surface. The pH at this site was lower than in the deciduous area and more variable at depth (Table 2).

Area 2

Work area 2 consisted of 40 acres. Before the reclamation, it was a poorly-graded surface mine with two drift mine openings into the highwall. In 1967 the western 25 percent of the area was graded relatively flat (pasture backfill) and the eastern portion was a swallowtail backfill. The bench and outslope received agricultural limestone at the rate of 2.5 tons per acre. The bench received 1,000 pounds of 10-10-10 fertilizer per acre in April 1968 and was planted to grasses and legumes in May (Table 1). The outslope was hydroseeded with fertilizer, grass/legume seeds, black locust seeds (6 pounds per acre), and 1000 pounds per acre of mulch. Black alder and larch were hand-planted at 600 trees per acre.

Vegetative growth was poor on the western half of the area at first. In the spring of 1969, this area was reseeded with black locust which did not grow. The area remained relatively bare until 1971, when a good growth of lespedeza developed on the bench.

In 1973, an evaluation found there was a 60 percent survival of trees with the average height of larch being 7 feet and alder 8 feet. Grasses and legumes covered 95 percent of the area and only two bare spots were greater than one half acre.

A May 1976 evaluation reported that larch, locust, and alder were the primary trees. The alder and hydroseeded locust were 4 to 12 feet tall. The alder stand was poor and many trees were in poor health. Of the herbaceous species planted, only tall fescue and lespedeza persisted.

In order to examine the area in some detail during 1985, a plot was marked off extending from the highwall, across the bench, and over the crest of the outslope. A strip 100 feet wide and over 300 feet in length was then subdivided into eight regions judged to represent geomorphic and successional differences (Figure 4).

The following are detailed observations of the regions within Plot 2-1; Figure 4 schematically depicts this information. The highwall extended 42 feet above the level of the inner bench. Numerous volunteer trees populate the colluvial material slumped at the base of the highwall; these were dominated by cottonwood, maple, yellow poplar, and sassafras, with a wild cherry and black locust noted about halfway up the highwall. All of the trees had seed sources in the forest above the highwall. The underbrush was composed of lespedeza, fescue, ironweed, and small trees.

The inner bench section contained 11 volunteer maples that ranged in height up to 9 feet. Ironweed was common, with mixtures of oatgrass, bromesedge, fescue, and lespedeza covering essentially all of the soil. A few small blackberry plants were noted occasionally, and acid-tolerant green moss thrived in damp spots. Oatgrass covered nearly 100 percent of the west side of this section grading to zero at the east side, which contained nearly 100 percent lespedeza.

The section including the drainageway road contained six volunteer maple, up to 6 feet high, and a few blackberry plants less than 1 foot high. Bromesedge was prominent throughout this section, with a few oatgrass plants and essentially no lespedeza. Two unidentified shrubs were obvious in this section, as were two soil areas barren of any vegetation.

The roadway was rutted with the ruts serving as drainage channels. Small tufts of grass were found between the ruts, but otherwise the road was bare.

The section from the roadway to the tree line varied from a few mixed grasses and weeds, and square-yard areas of acid-tolerant mosses, to 20 large trees at the southern part of this section. Eighteen maples, up to 18 feet high, one cottonwood measuring 29 feet, numerous small blackberries, and mixed ironweed, lespedeza, and several moss species were enumerated.

The treeline was defined as a distinct section which appeared to have benefitted from seedfall from the native hardwoods above the highwall 130 feet to the north. Why this section of trees developed at this point was not evident. Maples ranged up to 26 feet and cottonwood up to 40 feet. A barren area of about 600 square feet was situated on the east side of this section and a portion of the northeast side of the adjacent outer bench. Large areas covered with moss were present, as well as an area with a thick growth of lespedeza.

The outer bench comprised a fairly large and irregular area, as depicted on Figure 4. It was mostly vegetated with volunteer trees and lespedeza remnant from the original planting in 1968. Maples, with several reaching 25 feet, cottonwood up to 22 feet, and a few black locust several feet high were noted. Clumps of various common grasses covered most of the section, but flourishing lespedeza covered the northwest corner and ironweed interspersed with lespedeza completely covered the southern quarter of this section.

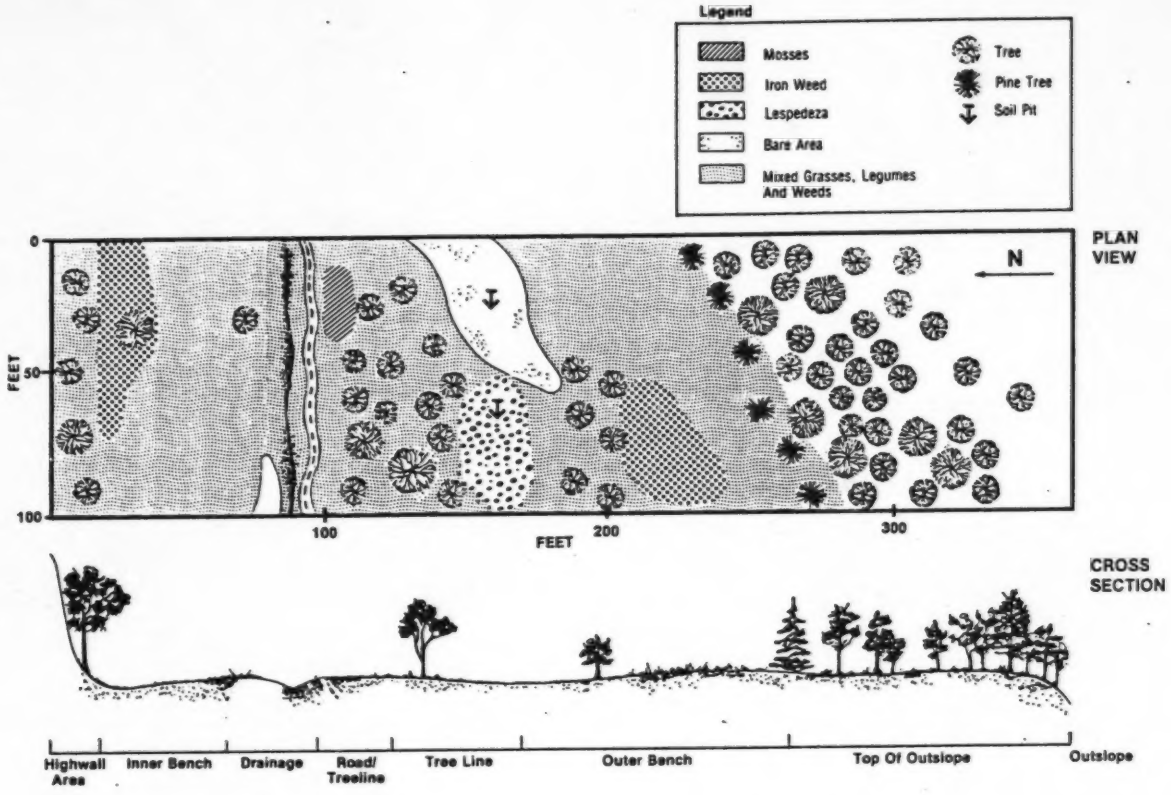

Figure 4: Grass Survival And Tree Invasion On Area 2 After 17 Years.

Soil pits were excavated within both the barren soil area and the lespedeza-covered areas of this section; about 2 inches of litter covered the mineral soil in the lespedeza area. Table 2 compares the pH observed from samples taken at these two areas. The pH value of 4.4 in the upper 4 inches of the vegetated area was approximately 0.8 units higher than the 3.6 readings for the same zone in the barren area. Data obtained prior to reclamation in 1968 showed the spoil material pH to range between 3.3 and 3.6 throughout this area. Data taken in 1985 show that there has been no change in soil pH in the area not covered with vegetation, but the pH has increased almost one-unit in the surface 6-inches where lespedeza completely covers the soil.

The top of the outslope consisted of dense tree cover; over 190 individuals with a dbh greater than 1 inch were counted within the 8,000 square feet examined at the top of this outslope. Pine and locust dominated a narrow strip along the top of the outslope at the border with the outer bench section. Thirteen pines (10 shortleaf and 3 virginia) ranging up to 36 feet high, with a dbh of 3.8 to 8.8 inches, and locust up to 40 feet high with a dbh of 5 to 6 inches were noted. One cottonwood attained 48 feet in height; average height of most trees observed in this section was 34 feet. Only one of the originally-planted larches was found, and it was 34 feet tall and had a dbh of 6 inches.

On the outslope itself, with a gradient of about 65 percent, a thick stand of trees had volunteered and formed a complete canopy. Maples were the dominant species. These were underlain by substantial leaf litter and a few scattered tufts of grass or other ground cover. No trees that were originally planted were found. Beyond the base of the outslope oak species dominated on the undisturbed forest. A few maple and cherry also were noted.

Conclusions

The evaluation team assembled in 1984 concurred that the Elkins Project effectively demonstrates the value of covering toxic spoil material, grading to promote runoff yet minimize erosion, and immediate seeding with herbaceous species after amendment with lime and fertilizer to agronomic specifications, in providing the most expedient and long-lasting reclamation. They noted abundant wildlife, including songbirds, game species, and prey. Where intensive land management was practiced, for example pastureland, a highly productive state had been attained on the previously mined land. However, each of the vegetation approaches demonstrated in the Elkins Project achieved a substantial degree of long-term success. Most erosion gullies that formed in early years as a result of poor runoff control persisted in 1984; but several gullies had become relatively stable and contained substantial herbaceous and woody vegetation cover.

The detailed study of three Areas in 1985 resulted in several detailed conclusions:

1. Adjacent undisturbed forest lands were the obvious seed source for the volunteer plants.

2. The most common volunteer herbaceous plants were ironweed (very dominant), wild strawberries, blackberries, bromsedge, and several other unidentified grasses and shrubs.

3. The grass species planted did not dominate any of the areas, but could be found as part of the grass/weed mixture in most areas.

4. S. Lespedeza has been a good persistent legume.

5. Mosses were a significant soil stabilizer in acidic moist areas.

6. Weeping lovegrass, which was a dominant species on acidic soil areas during the early years, was not observed at all after 17 years. This was anticipated, since in 1968 little use was made of species such as lovegrass which are readily overtaken by encroaching successional species.

7. The cottonwood and locust that were planted as seedlings did not have good survival rates, but these trees as well as maples, yellow poplar, cherry, and elm successfully volunteered into the reclaimed areas after several years.

8. Black alder was a successful nurse pioneer tree, but after 10-15 years, fungal attack decimated almost the entire population.

9. Shortleaf and Virginia pine were the most successful conifers planted, and grew to a height of approximately 30 feet and a dbh of 5 inches.

10. Over most of the area a surficial soil horizon is being enriched by organic matter from decaying grass and tree litter.

11. Root penetration was to the bottom of all soil pits (20 inches) where vegetation was present.

12. Based upon five soil sample pits, the soil pH is within a range of 3-5 and demonstrates the influence of the acidic parent rock on the soil properties. Poorer growth was observed in the lower pH soils.

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